OPTIMIZATION OF LUBRICATION TECHNIQUES ON MACHINING PERFORMANCE OF ALUMINIUM ALLOY 319

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Doctor of Philosophy
(MANUFACTURING ENGINEERING)

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SUPERVISOR'S DECLARATION

We hereby declare that We have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Doctor of Philosophy (Manufacturing Engineering)

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STUDENT’S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at University Malaysia Pahang or any other institutions.

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ABSTRAK

Secara tradisinya, pemilihan kaedah pemotongan untuk pemesinan hanya diserahkan kepada pengendali mesin. Di industri, proses pemesinan hanya bergantung kepada pengalaman dan kemahiran operator mesin untuk mencapai pemilihan parameter pemotongan yang optimum. Kelemahan amalan yang tidak saintifik ini menyebabkan penurunanan didalam produktiviti kerana penggunaan keupayaan pemesinan yang tidak konsisten. Cabaran industri didalam pemesinan moden tertumpu pada prestasi pemesinan pada kekasaran permukaan, suhu dan kehausan alat pakai dengan mengurangkan penggunaan penyejuk. Objektif penyelidikan ini adalah untuk mengoptimumkan sistem muncung penyejukan dalam prestasi pemesinan aluminium aloi 319 (A319) untuk mencapai kekasaran permukaan yang baik, suhu yang lebih rendah dan meningkatkan jangka hayat mata alat dengan memilih parameter pemesinan yang sesuai bagi kelajuan pemotongan, kedalaman pemotongan dan kadar suapan. Sistem penyejuk yang digunakan adalah kering, basah dan muncung penyejukan yang optimum bersaiz 1.0 mm, 2.0 mm, 3.0 mm 4.0 mm dan 5.0 mm pada kekasaran permukaan, suhu dan jangka hayat mata alat menggunakan Respond Surface Method (RSM) pada mesin CNC Lathe dengan 2 pergerakan paksi. Kekasaran permukaan diukur menggunakan Surface Roughness Tester, suhu diukur menggunakan Thermometer Laser Inframerah dan jangka hayat mata alat diukur menggunakan Tool Maker Mikroskop. Minyak larut sintetik, mata alat bersalut Al_2 O_3 cemented carbide dan aluminium aloi 319 digunakan sebagai alat pemotong dan bahan kerja. Kesan dari parameter pemotongan terhadap kekasaran permukaan, suhu dan jangka hayat mata alat dianalisis dengan menggunakan kaedah Analisis Varians (ANOVA) dan untuk mencapai prestasi pemesinan yang optimum dengan menggunakan Respond Surface Method (RSM). Pengoptimuman pelbagai parameter pemotong digunakan untuk memastikan kualiti produk dan mengurangkan kesan tenaga pemesinan. Hasil daripada eksperimen ini menunjukkan bahawa saiz muncung penyejuk bersaiz 1.0 mm memberi kekasaran permukaan yang baik, suhu yang lebih rendah dan memanjangkan jangka hayat alat mata berbanding muncung penyejuk bersaiz 2.0 mm, 3.0 mm, 4.0 mm dan 5.0 mm. Didalam eksperimen teknik pelinciran, faktor utama yang dianalisis oleh ANOVA adalah yang mempengaruhi kekasaran permukaan, suhu dan jangka hayat alat mata sebagai prestasi pemesinan adalah saiz muncung sebanyak 1.0 mm. Kelajuan pemotongan 270 m/min, kedalaman pemotongan 0.20 mm, kadar suapan 0.08 mm/min dan muncung teknik pelinciran bersaiz 1.0 mm adalah parameter optimum untuk meningkatkan dan mencapai kekasaran permukaan 0.94 μm Ra, suhu 91℃ dan jangka kehausan alat mata 0.48 mm dan 120 minit untuk masa jangka hayat mata pemesinan Penentuan parameter yang optimum telah disahkan dengan pengesahan eksperimen dengan ralat 4 peratus maksimum dan memperolehi nilai keinginan optimum 0.935 untuk kelajuan pemotongan, kedalaman potongan, kadar suapan dan muncung penyejuk 1.0 mm. Kesimpulannya, prestasi keseluruhan yang optimum dari segi kekasaran permukaan, suhu dan jangka hayat alat mata dengan saiz muncung penyejuk bersaiz yang paling kecil dan parameter pemotongan yang berbeza boleh dibangunkan menggunakan teknik RSM. Penyelidikan semasa juga bermanfaat untuk meminimumkan dan meningkatkan produktiviti dalam industri pemesinan. Oleh itu, dapat mengurangkan kebergantungan pada pengalaman dan kemahiran operator pemesinan.

ABSTRACT

Traditionally, the selection of cutting parameters for machining was left to the machine operator. In industries, the machining parameters are dependent on the experience and skill of the machine operator to achieve an optimal product quality. The disadvantage of this unscientific practice is low in productivity due to the sub optimal use of machining capability. The challenges in the modern machining industries are mainly focused on the machining performance on the surface roughness, temperature and tool life with reducing the coolant utilization. The objective of this research is to optimize nozzle lubricant system in machining performance of aluminum alloy 319 (A319) to achieve a good surface roughness, lower temperature and increased tool wear by selecting suitable machining parameters of cutting speed, depth of cut and feed rate. The coolant system used are dry, wet and optimum coolant nozzle size of 1.0 mm, 2.0 mm, 3.0 mm 4.0 mm and 5.0 mm on the surface roughness, temperature and tool life using Respond Surface Method (RSM) on the CNC Lathe machine with 2 axes movements. The surface roughness is measured using Surface Roughness Tester, temperature is measured using Infrared Laser Thermometer and tool wear is measured using Tool Maker's Microscope. The synthetic soluble oils, coated cemented carbide $Al_2\ O_3$ insert and Aluminum alloy 319 were used as a cutting tool and workpiece material respectively. The effect of cutting parameters towards surface roughness, temperature and tool wear were analyzed using Analysis of Variance (ANOVA) method and to achieve optimum machining performance by using Respond Surface Method (RSM). Multi-optimization of cutting parameters is used in ensuring product quality and minimizing the energy effects of machining. The results of the nozzle size of 1.0 mm shows a good surface roughness, lower temperature and reduced tool wear compared to 2.0 mm, 3.0 mm, 4.0 mm and 5.0 mm nozzle size. In lubrication techniques experiment, the analysis using ANOVA show that the main factor affecting the surface roughness, temperature and tool wear as machining performance is the used nozzle size of 1.0 mm. Cutting speed of 270 m/min, depth of cut of 0.20 mm, feed rate of 0.08 mm/min and nozzle size lubrication techniques of 1.0 mm are the optimum parameters for improving and achieving the surface roughness of 0.94 µm Ra, temperature of 91°C, tool wear length of 0.48 mm and the machining time taken is 120 minutes for tool life. The optimum parameters setting are verified with experimental validation with maximum 4 percent error and obtained optimal desirability value of 0.935 for the respective values of cutting speed, depth of cut, feed rate and coolant nozzle of 1.0 mm. In conclusion, the optimum overall performance in terms of surface roughness, temperature and tool wear with the smallest orifice size coolant and different cutting parameters can be developed using RSM technique. Current research is also beneficial to minimize and improve the productivity in machining industries. Consequently, reducing the dependent on the machining operators experience and skill.

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LIST OF SYMBOLS

Al	Aluminium
C	Carbon
Cr	Chromium
CCD	Central Composite Design
°C	Degree Celsius
C	Taylor's Constant
Cu	Copper
Dia or Ø	Diameter
D	Depth of cut
Fe	Iron
H.s.s.	High Speed Steel
L or Lg	Length
Mach	Machine
Math	Material
N	Nitrogen
N	Taylor's Exponential
R_a	Average Surface Roughness, µm
Si	Silicon
in/rev	Inches Per Minute
Ti	Titanium
V_c	Cutting Speed
WC	Tungsten Carbide
%	Percent
T	Tool Life
A	Angle
Θ	Polar Coordinate

LIST OF ABBREVIATIONS

Al_2O_3	Aluminium Oxide
ANOVA	Analysis of Variance
C	Taylor’s Constant
CNC	Computer Numerical Control
CCD	Central Composite Design
D	Diameter (mm)
D	Depth of cut (mm)
DOE	Design of Experiment
F	Cutting Feed
ISO	International Organization For Standardization
FW	Flank Wear
MM	Millimetre
MIN	Minute
MRR	Material Removal Rate
MQL	Minimum Quantity Lubrication
N	Taylor’s Exponential
QTY	Quantity
PVD	Physical Vapor Deposition
RSM	Response Surface Methodology
RPM	Revolution of Experiment
SEM	Scanning Electron Microscope
Ti6A14V	A type of Titanium Aluminium -Vanadium alloy
TiAIN	Titanium Aluminium Nitride
TiN	Titanium Nitride
T	Tool Life
TYP	Typical
3D	Three Dimensional
Wt%	Weight %

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